

CLAIMS

1. A method for preparing a polysuccinimide, which comprises, subjecting aspartic acid to polymerization in a solvent of supercritical fluid to form a polysuccinimide; wherein said supercritical fluid is selected from the group consisting of CO₂, NH₃, H₂O, N₂O, xenon, krypton, methane, ethane, ethylene, propane, pentane, methanol, ethanol, isopropanol, isobutanol, CClF₃, CFH₃, cyclohexanol, CS₂, and a mixture thereof; and wherein the supercritical fluid is used in conjunction with a cosolvent.
2. The method of Claim 1, wherein the cosolvent is selected from the group consisting of trans-2-hexenyl acetate, ethyl trans-3-hexenoate, methyl caproate, isobutyl isobutyrate, butyl acetate, butyl methacrylate, hexyl acetate, butyl butyrate, pentyl propionate, methyl ethanoate, ethyl caproate, methyl dodecanoate, 2-ethylbutyl acetate, methyl oleate, dodecyl acetate, methyl tridecanoate, soybean oil methyl esters, hexane, heptane, tetradecane, hexadecane, toluene, 1-hexadecene, 1-dodecanol, 1-nonanol and a mixture thereof.
3. The method of Claim 1, wherein said supercritical fluid is maintained at a pressure of from about 500 psi to about 2500 psi.
4. The method of Claim 1, wherein said supercritical fluid is maintained at a pressure of from about 700 psi to about 2000 psi.
5. The method of Claim 1, wherein said supercritical fluid is maintained at a temperature of from about 50 °C to about 300 °C.
6. The method of Claim 1, wherein said supercritical fluid is maintained at a temperature of from about 100 °C to about 250 °C.
7. The method of Claim 1, wherein the weight average molecular weight of the polysuccinimide is in the order of from about 2,000 to about 10,000 Dalton.
8. The method of Claim 1, wherein the weight average molecular weight of the polysuccinimide is in the order of from about 3,000 to about 5,000 Daltons.
9. The method of Claim 1, wherein said polymerization is carried out in the presence of a stabilizer.

10. The method of Claim 9, wherein said stabilizer is a thermal stabilizer, an antioxidant or a mixture thereof.
11. A method for preparing a polysuccinimide, which comprises, subjecting aspartic acid to polymerization in a solvent of supercritical fluid to form a polysuccinimide, wherein said polymerization is carried out in the presence of a catalyst to form the polysuccinimide.
12. The method of Claim 11, wherein said catalyst is phosphoric acid.
13. The method of Claim 11, wherein said polysuccinimide exhibits a weight average molecular weight of up to 300,000 Daltons.
14. A method for preparing a polysuccinimide, which comprises, subjecting aspartic acid to polymerization in a solvent of supercritical fluid to form a polysuccinimide; wherein said polysuccinimide is blended with an additive in the supercritical fluid.
15. The method of Claim 14, wherein said additive is selected from the group consisting of a stabilizer, an antioxidant, a colorant, a plasticizer, a reinforcing agent, a filler, and a lubricant.
16. The method of Claim 15, wherein said stabilizer is a heat stabilizer or an ultraviolet stabilizer.
17. The method of Claim 15, wherein said antioxidant is selected from the group consisting of a hindered phenol, an amine, a phosphite, a thioester, a sulfite, a metal salt of a dithioacid.
18. A method for preparing a copolymer containing copolymerized aspartate units and succinimide units which comprises, subjecting a comonomer mixture of aspartic acid and a salt of aspartic acid to polymerization in a solvent of a supercritical fluid; wherein said comonomer mixture is prepared by drying a solution of a salt of aspartic acid having a cation which does not volatilize during the drying and a salt of aspartic acid having a cation which at least partially volatilizes to free aspartic acid during the drying; wherein said supercritical fluid is selected from the group consisting of CO₂, NH₃, H₂O, N₂O, xenon, krypton, methane, ethane, ethylene, propane, pentane, methanol,

ethanol, isopropanol, isobutanol, CClF_3 , CFH_3 , cyclohexanol, CS_2 , and a mixture thereof; and wherein the supercritical fluid solvent is used in conjunction with a cosolvent.

19. The method of Claim 18, wherein the cosolvent is selected from the group consisting of trans-2-hexenyl acetate, ethyl trans-3-hexenoate, methyl caproate, isobutyl isobutyrate, butyl acetate, butyl methacrylate, and hexyl acetate, butyl butyrate, pentyl propionate, methyl ethanoate, ethyl caproate, methyl dodecanoate, 2-ethylbutyl acetate, methyl oleate, dodecyl acetate, methyl tridecanoate, soybean oil methyl esters, hexane, heptane, tetradecane, hexadecane, toluene, 1-hexadecene, 1-dodecanol, 1-nonanol and a mixture thereof.
20. The method of Claim 18, wherein said supercritical fluid is maintained at a pressure of from about 500 psi to about 2500 psi.
21. The method of Claim 18, wherein said supercritical fluid is maintained at a pressure of from about 700 psi to about 2000 psi..
22. The method of Claim 18, wherein said supercritical fluid is maintained at a temperature of from about 50 °C to about 250 °C.
23. The method of Claim 18, wherein said supercritical fluid is maintained at a temperature of from about 100 °C to about 250 °C.
24. The method of Claim 18, wherein the weight average molecular weight of said copolymer was in the order of about 2,000 to about 10,000 Dalton.
25. The method of Claim 18, wherein the weight average molecular weight of said copolymer was in the order of from about 3,000 to about 5,000 Daltons.
26. The method of Claim 18, wherein said polymerization is carried out in the presence of a stabilizer.
27. The method of Claim 26, wherein said stabilizer is a thermal stabilizer, an antioxidant or a mixture thereof.
28. A method for preparing a copolymer containing copolymerized aspartate units and succinimide units which comprises, subjecting a comonomer mixture of

aspartic acid and a salt of aspartic acid to polymerization in a solvent of a supercritical fluid; wherein said comonomer mixture is prepared by drying a solution of a salt of aspartic acid having a cation which does not volatilize during the drying and a salt of aspartic acid having a cation which at least partially volatilizes to free aspartic acid during the drying; wherein said supercritical fluid is selected from the group consisting of CO₂, NH₃, H₂O, N₂O, xenon, krypton, methane, ethane, ethylene, propane, pentane, methanol, ethanol, isopropanol, isobutanol, CCIF₃, CFH₃, cyclohexanol, CS₂, and a mixture thereof; wherein said polymerization is carried out in the presence of a catalyst to form the copolymer containing aspartate units and succinimide units.

29. The method of Claim 28, wherein said catalyst is a Lewis acid.
30. The method of Claim 28, wherein said copolymer exhibits a weight average molecular weight of up to 300,000 Daltons.
31. The method of Claim 18, wherein said copolymer was blended with an additive in the supercritical fluid.
32. The method of Claim 31, wherein said additive is selected from the group consisting of a stabilizer, an antioxidant, a colorant, a plasticizer, a reinforcing agent, a filler, and a lubricant.
33. The method of Claim 32, wherein said stabilizer is a heat stabilizer or an ultraviolet stabilizer.
34. The method of Claim 32, wherein said antioxidant is selected from the group consisting of a hindered phenol, an amine, a phosphite, a thioester, a sulfite, a metal salt of a dithioacid.
35. A method for preparing a copolymer containing succinimide moieties, which comprises, polymerizing L-aspartic acid in a supercritical fluid, in the presence of an end-capping initiator to form the copolymer.
36. The method of Claim 35, wherein said end-capping initiator is selected from the group consisting of an anhydride, a carboxylic acid and an amine.

37. The method of Claim 36, wherein said anhydride is selected from the group consisting of succinic anhydride, phthalic anhydride, maleic anhydride, alkenyl succinic anhydride, 1,2,4-benzenetricarboxylic anhydride; cis-1,2,3,6-tetrahydrophthalic anhydride and 1,2-cyclohexane dicarboxylic anhydride.
38. The method of Claim 36, wherein said carboxylic acid is selected from the group consisting of benzoic acid, thiolsuccinic acid and terephthalic acid.
39. The method of Claim 36, wherein said amine is represented by the formula RR_1NH , where R, and R_1 , are the same or different radicals selected from the group consisting of an alkyl, a substituted alkyl, an alkenyl, an aryl, aryl-alkyl, and a substitute aryl radical.
40. The method of Claim 39, wherein said alkyl is selected from the group consisting of a methyl, an ethyl, a *n*-propyl, an isopropyl, a *n*-butyl, an isobutyl, a *sec*-butyl, a *n*-amyl, an isoamyl, a *n*-hexyl, a *n*-octyl, a capril, a *n*-decyl, a lauryl, a myristyl, a cetyl, and a stearyl.
41. The method of Claim 39, wherein said substituted alkyl is hydroxyethyl.
42. The method of Claim 39, wherein said alkenyl is allyl.
43. The method of Claim 39, wherein said aryl is phenyl.
44. The method of Claim 39, wherein said aryl-alkyl is benzyl.
45. The method of Claim 39, wherein said substituted aryl is selected from the group consisting of an alkylphenyl, a chlorophenyl and a nitrophenyl.
46. The method of Claim 36, wherein said amine is selected from the group consisting of an aliphatic amine, an aliphatic diamine, an aliphatic hydroxylamine, an aminoethoxylate, an aromatic amine, and an aromatic diamine.
47. The method of Claim 46, wherein said aliphatic amine is selected from the group consisting of methylamine, dimethylamine, ethylamine, diethylamine, *n*-propylamine, di-*n*-propylamine, *n*-butylamine, *n*-amylamine, *n*-hexylamine and laurylamine.

48. The method of Claim 46, wherein said aliphatic diamine is selected from the group consisting of ethylenediamine, trimethylenediamine, tetramethylenediamine, pentamethylenediamine, hexamethylenediamine.
49. The method of Claim 46, wherein said aliphatic hydroxylamine is selected from the group consisting of ethanolamine, diethanolamine and triethanolamine.
50. The method of Claim 46, wherein said aromatic amine is selected from the group consisting of methylaniline, dimethylaniline, diethylaniline, o-toluidine, m-toluidine and p-toluidine.
51. The method of Claim 46, wherein said aromatic diamine is selected from the group consisting of o-phenylenediamine, m-phenylenediamine and p-phenylenediamine.
52. The method of Claim 35, wherein said copolymer contains an anhydride end group.
53. The method of claim 52, herein said anhydride reacts with a nucleophile.
54. The method of Claim 53, wherein said nucleophile is selected from the group consisting of an aminoethoxylate, a hydrophobic amine, a hydroxyl terminated materials a poly(vinyl alcohol), a polyester, a polyamide, a polysaccharide, a dextran, a cellulose, a protein, a dye and a UV absorber.
55. The method of Claim 54, wherein said polysaccharide is starch.
56. The method of Claim 35, wherein said copolymer is a prepolymer.
57. The method of Claim 56, wherein said prepolymer exhibits a weight average molecular weight of from 100 to 1,000 Daltons.
58. The method of Claim 56, wherein said prepolymer is further polymerized by a method selected from the group consisting of thermal process, a supercritical fluid process, in the molten phase and in the solid phase.
59. The method of Claim 35, wherein said end-capping initiator and said L-aspartic acid are present in a ratio of from 1:1 to 1:10.
60. The method of Claim 35, wherein said end-capping initiator and said L-aspartic acid are present in a ratio of from 1:1 to 1:5.

61. The method of Claim 35, further comprising a monomer selected from the group consisting of an amino acid, a hydroxy acid, a combination of a diamine with a dicarboxylate and a combination of a diol with a carboxylate.
62. The method of Claim 35, wherein said copolymer is an oligomer.
63. The method of Claim 35, wherein said copolymer exhibits a weight average molecular weight of from 1,000 to 150,000.
64. The method of Claim 35, wherein said copolymer exhibits a weight average molecular weight of from 1,000 to 10,000.
65. The method of Claim 62, wherein said oligomer undergoes chain extension in an extruder.
66. The method of Claim 35, wherein a succinimide moiety of said copolymer reacts with a material selected from the group consisting of an aminoethoxylate, a hydrophobic amine and a hydroxyl terminated material to form a graft copolymer.
67. The method of Claim 35, wherein an anhydride end of said copolymer further reacts with a primary or secondary amine.
68. The method of Claim 35, wherein said polymerization is carried out in the presence of a stabilizer.
69. The method of Claim 68, wherein said stabilizer is selected from the group consisting of a thermal stabilizer, an antioxidant and a mixture thereof.
70. A method for preparing a copolymer of L-aspartic acid, which comprises, polymerizing L-aspartic acid in a supercritical fluid, in the presence of an end-capping initiator and a catalyst to form the copolymer of L-aspartic acid.
71. The method of Claim 70, wherein said catalyst is selected from the group consisting of phosphoric acid, a Lewis acid and an organometallic catalyst.
72. The method of Claim 71, wherein said organometallic catalyst is tin octanoate.
73. The method of Claim 35, wherein said copolymer is isolated and blended with a polymer additive.

74. The method of Claim 73, wherein said polymer additive is selected from the group consisting of a stabilizer, an antioxidant, a hindered phenol, an amine, a phosphite, a thioester, a sulfite, a metal salt of a dithioacid, a colorant, a plasticizer, a reinforcing agent and a lubricant.
75. An article prepared by processing the copolymer of Claim 35.
76. A method for preparing a polysuccinimide derivative, which comprises, forming said polysuccinimide in a supercritical fluid, and subjecting the polysuccinimide, in the supercritical fluid, to a ring-opening reaction.
77. The method of Claim 76, wherein said ring-opening reaction is carried out in the presence of an amine.
78. The method of Claim 77, further comprising water as a cosolvent.
79. The method of Claim 77, wherein said amine is a combination of amines.
80. The method of Claim 79, wherein said combination of amines is comprised of ammonium hydroxide and 2-aminoethanol to form a resin.
81. The method of Claim 80, wherein said resin contains a free carboxylic acid salt and the amides of ammonia and aminoethanol.
82. The method of Claim 77, wherein said amine has the general formula:
 $R_1R_2R_3N$; where R_1 , R_2 , and R_3 are the same or different radicals selected from the group consisting of hydrogen, an alkyl, a substituted alkyl, an alkenyl, an aryl, an aryl-alkyl, and a substituted aryl radical.
83. The method of Claim 82, wherein said alkyl is selected from the group consisting of methyl, ethyl, *n*-propyl, isopropyl, *n*-butyl, isobutyl, *sec*-butyl, *t*-butyl, *n*-amyl, isoamyl, *t*-amyl, *n*-hexyl, *n*-octyl, capril, *n*-decyl, lauryl, myristyl, cetyl, and stearyl.
84. The method of Claim 82, wherein said substituted alkyl is hydroxyethyl.
85. The method of Claim 82, wherein said alkenyl is allyl.
86. The method of Claim 82, wherein said aryl is phenyl.
87. The method of Claim 82, wherein said aryl-alkyl is benzyl.
88. The method of Claim 82, wherein said substituted aryl radical is selected from the group consisting of alkylphenyl, chlorophenyl and nitrophenyl.

89. The method of Claim 77, wherein said amine is triethanol amine.
90. The method of Claim 77, wherein said amine is selected from the group consisting of aminopyrdine, imidazole and a polyamine.
91. The method of Claim 90, wherein said polyamine is selected from the group consisting of a gelatin, chitin, lysine, ornithine and melamine.
92. The method of Claim 77, wherein said amine is aminoethoxylate.
93. The method of Claim 76, wherein said polymerization is carried out in the presence of a stabilizer.
94. The method of Claim 93, wherein said stabilizer is selected from the group consisting of a thermal stabilizer, an antioxidant and a mixture thereof.
95. The copolymer formed by the method of Claim 35.
96. The derivative of the polysuccinimide formed by the method of Claim 76.
97. An article prepared by processing the derivative of the copolymer of Claim 35.
98. An article prepared by processing the derivative of the copolymer of Claim 76.
99. The article of Claim 97, wherein said processing is selected from the group consisting of extrusion, injection molding, blow molding and calendering.
100. The article of Claim 98, wherein said processing is selected from the group consisting of extrusion, injection molding, blow molding and calendering.